Quantum coherence versus thermal noise: Ultrafast Bose-like electron self-trapping in preheated diamond

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Ultrafast visible-range two-photon and carrier impact interband excitation of electron-hole plasma in natural monocrystalline diamond produces intense and unusual structured intra-gap UV-vis photoluminescence, representing electron self-trapping via multiple non-thermal TO/LO-phonon emission as Bose-Einstein condensation-like process. The photoluminescence intensity increases versus laser pulse energy with steeply decreasing power slopes, indicating two-photon excitation balanced by self-trapping, radiative and Auger-recombination plasma dynamics. Stationary variable preheating of the crystal rapidly damps the non-thermal Bose-like self-trapping process through thermally-activated spontaneous emission of competing TO/LO-biphonon. Photo-injected free electrons gain additional kinetic energy through free-carrier absorption and can be resonantly trapped into narrow-band intra-gap energy states of luminous centers, exhibiting rich photoluminescence spectral structures of metastable phonon progressions, unattainable via direct excitation. The resonant carrier trapping mechanism reveals the unprecedentedly ultrafine vibronic features of the phonon-mediated relaxation dynamics in the intra-gap luminous centers, opening the way for their detailed structural studies, modeling and harnessing in quantum optics.